IES Newsletter

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Director's Note

Global climate change is potentially one of the most serious environmental problems that human societies have ever had to face. Global climate change results from an increased concentration of so-called greenhouse gases in the atmosphere. Carbon dioxide, one of the major greenhouse gases, has been increasing in concentration since the mid-1950s, primarily due to the combustion of fossil fuels and to worldwide deforestation.

Global warming is one of the better-known consequences of higher concentrations of greenhouse gases. But a build-up of carbon dioxide in the atmosphere could have other environmental impacts as well. Plants — upon which most organisms depend for food — take up carbon dioxide during photosynthesis. Could they be affected by increased concentrations of this gas? As a Guggenheim Fellow, IES chemical ecologist Dr. Clive Jones investigated this question, studying the effects of environmental change on the food quality of plants. His findings are summarized in the cover story.

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Does Environmental Change Affect the Food Quality of Plants?

Natural ecosystems are very complex, so some ecologists use models that capture the essence of ecosystem complexity but can be controlled and replicated. The recently developed Ecotron facility, at the Centre for Population Biology at Imperial College at Silwood Park in Britain, is providing such models. The Ecotron's chambers, housing many identical, relatively simple, but fully functioning ecosystems, make the facility a potentially invaluable tool for increasing our understanding of real ecosystems.

IES researcher Dr. Clive Jones, recognizing the Ecotron's value as a unique research tool, has been virtually commuting to the British facility. His goal: to study the effects of global environmental change on food quality.

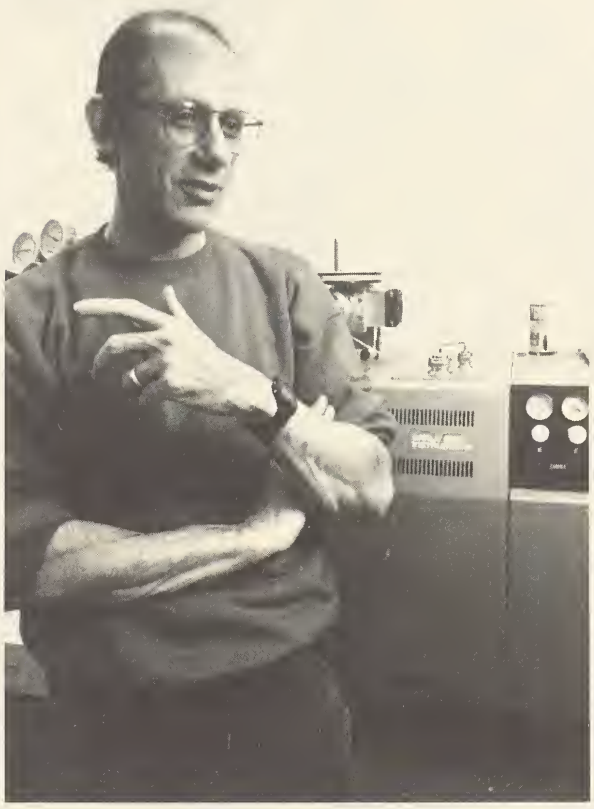
In 1994 Dr. Jones (below) received a prestigious Guggenheim Fellowship, which he used over the following year to relate global environmental change — particularly increases in atmospheric carbon dioxide — to the food quality of plants for other organisms. "Plant-eating animals, such as insects, and microorganisms such as plant pathogens and the microbes that decompose dead plants and recycle nutrients, are very much affected by the chemistry of living and dead plants," Dr. Jones explains. "Plant material tends to be good quality food to these organisms when it is high in nitrogen and low in defensive chemicals and lignin (a tough, rigid polymer that adds support and strength to a plant but is not easily digested or decomposed by other organisms). Conversely, plant material that is low in nitrogen but high in defensive chemicals and lignin is poor quality food.

"What we don't know is whether or not plant food quality is going to be better or worse as the global environment changes." It is important to know this because, directly or indirectly, most of the other organisms on the planet, including humans, depend on plants for food.

The Ecotron Ecosystems

The Ecotron facility, which began operation in 1991, is headed by Professor John Lawton (who is also an adjunct scientist at IES). At present the project is funded largely by England's National Environmental Research Council.

The Ecotron consists of 16 chambers, each 3 meters (10 feet) on a side, in which such variables as day length, atmospheric composition, temperature, and rainfall can be precisely controlled. Each chamber contains a simple natural ecosystem: soil, complete with resident earthworms, collembola (small mite-like animals that chew on leaf litter, fungi, etc.), woodlice, fungi and bacteria; a variety of plant species and the insects and snails that eat them; and insects that eat the insects that eat the plants. (To allow for experiments that include multiple generations of plants over a short time, the researchers have used a plant community of four weedy, fast-growing plant species: hairy buttercress, a mustard; an annual grass; and spurrey and tansy ragwort, two other common plants of waste ground.) These are fully functioning ecosystems, having much of the complexity of the real world yet affording the control and replication generally associated with experiments using single plants in pots.



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The Ecotron research team is looking at how each model ecosystem behaves, from overall carbon and nitrogen budgets to

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Food Quality, *from page 1*

individual organisms. So multifaceted and wide-ranging is this work that it requires close collaboration among several dozen scientists.

Changes in Food Quality in the Ecotron

Dr. Jones and colleagues on the Ecotron research team found that increased atmospheric carbon dioxide concentrations appear to decrease food quality by increasing the amounts of phenolic defensive compounds, chemicals that are also the precursors of lignin. These compounds increased in concentration in all four of the plant species in the ecosystem — but only once the soil nutrients were depleted (see box).

Because this carbon dioxide-induced increase in phenolics depends on soil nitrogen conditions, it does not show up at all in the first generation of plants but becomes a major effect by the second and third generation. This is because, as the plants grow, the availability of soil nitrogen declines. The fact that four quite different plant species respond similarly suggests that the underlying biochemical controls on phenolic production may be the same in many plant species.

Most importantly, the findings suggest that the effects of elevated carbon dioxide on food quality will depend on the nitrogen status of the soil. So, in ecosystems with high soil nitrogen, elevated carbon dioxide would be expected to have little effect on food quality, while in ecosystems with low soil nitrogen, elevated carbon dioxide would be expected to decrease food quality.

Dr. Jones anticipates additional Ecotron studies will show whether or not the changes in plant chemistry the collaborators have seen will in turn affect the abundance of the insects and other animals feeding on these plants and the rate at which the dead plant material decomposes.

While he cannot be sure that the effects seen in the Ecotron ecosystems will occur in the more complex ecosystems in nature, Dr. Jones notes that the Ecotron experiments have revealed a new, complex interaction between elevated carbon dioxide and soil nitrogen that was not previously recognized. It now should be possible to test these findings elsewhere and see if indeed the controlled and replicated Ecotron ecosystems are a valuable tool in unraveling nature's complexity.

What Determines the Amounts of Phenolics in a Plant?

All higher plants contain phenolics. These chemicals play key roles in determining food quality to other organisms. For example, lignin — the organic compound, tough to digest and decompose, that makes wood woody — is made entirely of phenolics.

Current thinking about phenolics predicts that more should be made when more carbon is taken up by plants. As photosynthesis — plants' carbon-fixing process — increases with increased atmospheric carbon dioxide, phenolics should increase. But this explanation does not fit with the results found in the Ecotron: the amount of plant phenolics produced under elevated carbon dioxide as compared to ambient carbon dioxide actually was controlled by the amount of soil nitrogen.

To explain these results, Dr. Clive Jones and his colleague Dr. Susan Hartley of the Institute of Terrestrial Ecology, Banchory, Scotland, have developed a new model of control over phenolic production in plants.

Drs. Hartley and Jones start with the knowledge that the production in the plant of both phenolics and the proteins used in growth and photosynthesis requires the same chemical compound — the amino acid phenylalanine. The two pathways "compete" for this amino acid. The scientists' hypothesis is that when soil nitrogen — a nutrient — is readily available, plants tend to make a lot of protein for growth and very little phenylalanine goes to phenolics. When plants are grown under increased levels of atmospheric carbon dioxide they need less protein for photosynthesis, but the savings in phenylalanine still go to protein for growth and not to phenolics.

However, when nitrogen in the soil is limited, protein synthesis for plant growth slows down. When plants grow at low levels of nitrogen and high levels of carbon dioxide, the protein savings from increased efficiency of photosynthesis frees up phenylalanine, which then is used to make phenolics.

IES Graduate Student Wins Robert Whittaker Award

Bacteria are the most diverse and abundant organisms on Earth. They are specialists, with species growing just about everywhere and performing a myriad of functions. Some live in snow, while others survive near deep ocean vents where the water temperature reaches 350°C (662°F). Some thrive in or on animals and plants, others in soils and in stream sediments. Some are harmful — pathogenic bacteria produce toxic substances when they enter our bodies, often resulting in infection or disease — while others are useful, for example the nitrogen-fixing bacteria that live in nodules on the roots of plants like clover and alfalfa and convert nitrogen gas to a form of nitrogen that plants need for growth.

Given the vast numbers of bacterial species that exist, the contributions of the majority to their ecosystems are as yet unknown. New knowledge is being created all the time, thanks to the work of scientists like IES graduate student William Sobczak. Knowing that microorganisms influence, if not regulate, the chemistry of water, Sobczak is investigating the relationship between bacteria in stream sediments and the chemistry of stream water.

One of the chemicals found naturally in stream water is organic carbon, which is an end product of the decomposition of forest debris, algae and other formerly-living material. Organic carbon is a nutrient, a requirement for bacterial growth, and at his field sites Sobczak is studying how much organic carbon is available to fuel the bacteria that live in stream sediments. He is investigating changes in water chemistry and microbial ecology, measuring the amount of organic carbon and its availability to bacteria in different subsurface habitats.

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Adventures in Scientific Thinking

by Ann Botshon

For over a decade, the Institute of Ecosystem Studies has supported curriculum development and local school programs to sharpen young people's awareness of the natural world. IES educators also recognize the ongoing need to develop a large corps of teachers knowledgeable about ecology and thereby able to foster the development of students' scientific thinking skills.

Two new books written by IES research and development specialist Ms. Kathleen Hogan aim to do just that. *Rita*, a novel written for young people, shows that it can be fun and satisfying to think scientifically. Accompanying *Rita* is a guidebook, *Promoting Student Thinking: A Teacher's Guide to Linking Science and Literature Through Rita*, that leads teachers through each chapter in the novel with suggestions for facilitating student discussions, writing and projects.

Both new publications are important supplements to *Eco-Inquiry: A guide to ecological learning experiences for the upper elementary/middle grades*, written by Hogan and published in 1994. This earlier publication offers a series of experiences, applicable in schools throughout the country, to help encourage scientific awareness and thoughtful inquiry in students.

"I wrote *Rita* to tackle the problem of 'transfer', the effort to prevent knowledge and skills learned in school from becoming inert in other contexts," Hogan, at right, explains. "I wanted to create a role model who applies scientific thinking skills and ecological knowledge to everyday situations." *Rita* is the story of a girl who becomes fascinated with a small marsh near her school. Discovering that the wetland is slated for development, she learns more about its plants and animals and mobilizes her friends to help educate the community about its value.

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"A central goal of *Rita* is to show what it means to think critically, creatively, fluidly and analytically — in other words, scientifically — in everyday life," says Hogan. "This whole project is an effort to focus students on using their minds well." *Rita* aims to impart the idea that students can become more capable thinkers by taking responsibility for their own learning.

The exercises in the new guidebook, keyed to the novel, give all teachers a way to make the best use of science material. "Elementary teachers who have expertise in language arts find it appealing to teach science through literature," Hogan explains.

The guidebook also provides suggestions for activities in which students can apply their skills and knowledge to investigating environmental issues in their own communities, encouraging them to decide for themselves what projects and values are important. In every community there's an ecological issue that resonates with young people, and that can be a gateway into other ecological explorations.

Rita and the *Teacher's Guide* are being published by Kendall/Hunt Publishing Company. The project is supported in part by the National Science Foundation and public funds from the New York State Council on the Arts. Both publications are expected to be available this spring. Ordering information will be in an upcoming issue of the IES NEWSLETTER.

Award, *from page 2*

Mr. Sobczak's research sites are at streams across the Hudson River Valley, from relatively pristine forested catchments in the Catskill Mountains to areas where agriculture has an impact on water quality. One of his sites is along the East Branch of Wappinger Creek, which meanders through the Institute's forests and lowlands. Not far from where Sobczak sits in the photograph at left is a bend in the creek where stream water on its way downstream passes through sediment that has built up along the inside bank. Because microorganisms anchor to pebbles and sand grains, this area is microbially-rich and therefore is an excellent habitat to investigate potential changes in organic carbon. At shallow wells, Sobczak pumps groundwater from sediments at a level just below that of the stream's channel, then takes the samples to the IES laboratories where he analyzes them for bacterial communities and water chemistry.

Findings from Sobczak's research will contribute to the considerable body of knowledge that has been amassed by IES and Cornell University ecologists about the transport of organic matter through the Hudson River watershed. The Hudson River's many tributaries have a direct effect on the water quality of its mainstem. For example, the transport of nutrient-rich, high organic stream water from catchments in agricultural regions within the Hudson River watershed can influence greatly the biota and chemistry of the river. Mr. Sobczak has demonstrated that organic matter from the tributaries he is studying differs in its availability to bacteria and hence in its importance to the Hudson River's food web and water quality.

Robert H. Whittaker Award

Dr. Robert H. Whittaker was an internationally recognized plant community and ecosystem ecologist at Cornell University, where he was a professor in the Section of Ecology and Systematics. Now, each year an award is made in his name for the best oral presentation at the annual Cornell University's Section of Ecology and Systematics' Annual Graduate Student Symposium. This year's symposium, attended by graduate students and faculty, was held on January 18 and 19, and over 30 scientists presented papers on their current research. Mr. Sobczak, whose paper described the "Microbial Metabolism of Dissolved Organic Carbon in Stream Hyporheic Zones", was a co-recipient of the Whittaker Award.

* * * * *

Mr. William Sobczak is a graduate student at the Institute of Ecosystem Studies and Cornell University, doing research toward a Ph.D. in collaboration with his IES thesis advisor Dr. Stuart E.G. Findlay and his Cornell thesis advisor Dr. Robert W. Howarth. His research was funded first by the Hudson River Foundation and is supported now by a National Science Foundation grant and a graduate fellowship from the Environmental Protection Agency.

Calendar

CONTINUING EDUCATION

Call the Continuing Education Program office at 914/677-9643 for information on **spring semester** classes, workshops and excursions. Early spring programs include:

Landscape Design

Apr. 20: **Field Course: Contour Plans**
Apr. 27: **Computer Graphics in Landscape Design**

Gardening

Apr. 11 (6 sessions): **Insect Pests and Diseases of Plants**
Apr. 13 (4 sessions): **Woody Plants**
Apr. 14: **Water Gardens**
Apr. 20: **Integrated Pest Management**
Apr. 20: **Raised Bed Vegetable Gardening**
Apr. 21: **Growing Herbs Indoors**
May 4: **Shade Gardening: Using the Eastern Deciduous Forest as a Design Model**

Natural Science Illustration

Apr. 27 & 28: **Pen & Ink I**

Workshops

Apr. 13: **Bringing Out the Best in Shrubs**
May 5: **Planting Noah's Garden**

Other Courses

May 1 (5 sessions): **Plant Pharmacy: Exploring Plants for Health Remedies**

SUNDAY ECOLOGY PROGRAMS

Free public programs are held on the first and third Sunday of the month, except over holiday weekends. Call 914/677-5359 to confirm the day's topic or, in case of poor weather, to learn the status of the day's program. The following programs begin at 2 p.m. at the Gifford House:

Apr. 21: **The Spring Fever Hike**, a walk led by Michael Weintraub
May 5: **A Stream Walk**, led by Dr. David Strayer
May 19: **Super Soil: The World Beneath Our Feet**, a walk led by Alan Lorifice

** We strongly recommend that participants wear long pants tucked into socks and sturdy waterproof footwear for all outdoor programs.*

IES SEMINARS

Free **scientific seminars** are held each Friday at 3:30 p.m. at the IES Auditorium:

Apr. 12: Title to be announced. Speaker: Dr. William Currie, The Ecosystems Center, Woods Hole, Massachusetts
Apr. 19: **The Evolution and Adaptive Significance of the Leafmining Habit**. Speaker: Dr. Edward F. Connor, Univ. of Virginia
Apr. 26: **Landscape Vegetation Modeling with Vital Attributes and Fuzzy Systems Theory**. Speaker: Dr. David W. Roberts, Utah State Univ.
May 3: **The Ecology of Fear: Consequences of Feeding Under Predation Risk**. Speaker: Dr. Joel Brown, Univ. of Illinois - Chicago
May 10: **Restoring Ecosystems for Endangered Species: The Acid Test of Wetland Ecology**. Speaker: Dr. Joy B. Zedler, Pacific Estuarine Research Lab, San Diego State Univ.

VOLUNTEER OPPORTUNITIES

Volunteers are needed to work with Gifford House Visitor and Education Program staff in ecology education for school groups, as trail monitors, and in the IES Gift Shop. To learn the responsibilities and benefits, call Ms. Su Marcy at 914/677-5359.

GREENHOUSE

The IES greenhouse, a year-round tropical plant paradise and a site for controlled environmental research, is open until 4:00 p.m. daily except public holidays. Admission is by free permit*.

HOURS

Winter hours: October 1 - April 30
Closed on public holidays.
Roadways are closed when snow-covered.

Public attractions are open Mon. - Sat., 9 a.m. - 4 p.m. & Sun. 1 - 4 p.m., with a free permit*.
The **IES Gift and Plant Shop** is open Mon.- Sat., 11a.m. - 4 p.m. & Sun. 1 -4 p.m. (The shop is closed weekdays from 1 - 1:30 p.m.)

** Free permits are required for visitors and are available at the Gift Shop daily until 3 p.m.*

IES GIFT AND PLANT SHOP

New in the Shop ... hand-painted gourd bird houses and feeders ... hand-painted rock paperweights ... IES postcards ... IES sweatshirts in new colors for spring ... **for children** ... Peterson's First Guides ... acid rain test kits ... books of science fair project ideas

•• **Gift Certificates** are available ••

Senior Citizens Days: 10% off on Wednesdays

MEMBERSHIP

Join the Institute of Ecosystem Studies. Benefits include a member's rate for courses & excursions, a 10% discount on Gift Shop purchases, a free subscription to the newsletter and participation in a reciprocal admissions program. Individual membership: $30; family membership: $40. Call Ms. Janice Claiborne at 914/677-5343.

The Institute's Aldo Leopold Society

In addition to receiving the benefits listed above, members of The Aldo Leopold Society are invited guests at spring and fall IES science updates. Call Ms. Jan Mittan at 914/677-5343.

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